Abstract

CUrisk, a computer fire risk analysis model, has been under development at Carleton University for over a decade. To better evaluate failure of building elements and spread of fire beyond the room of fire origin, this thesis developed and integrated into CUrisk a barrier failure model and a fire spread model.

A probabilistic fire spread model developed at Carleton University was incorporated into CUrisk system model. The role and position of the Fire Spread submodel were analyzed and changes to the system model and some other submodels were undertaken. With these modifications, CUrisk can employ the Fire Spread submodel to predict the fire hazard conditions in a building fire, and to use the results to predict the life risk and fire damages. Through a comprehensive case study of fire risk assessment of a six-storey residential building using the improved CUrisk, the Fire Spread submodel demonstrated the impacts of fire spread level on building occupant safety and fire losses.

To assist the development of a barrier failure model for CUrisk, six full-scale room fire tests were conducted and analyzed. The tests considered the following construction types: Cross Laminated Timber, Light Timber Frame and Light Steel Frame. The fire evolution and contribution of the timber assembly components to the room fire were investigated. The response of assembly components in the fire were studied as well. Findings suggest that the barrier failure characteristics of a building assembly in an arbitrary real fire might be very different than its performance in a fire resistance test. The test findings were extensively used to improve the CUrisk submodels and particularly to develop the barrier failure model.

A barrier failure model was developed based on the concept of component subtractive method. The temperature profile of a building assembly is calculated by a one-dimensional finite difference heat transfer approach. In conjunction with the assembly component response and failure criterion, the deterministic heat transfer and component response model was developed that can calculate the temperature profile and response of assembly components as well as the charring depth in timber component. A probabilistic barrier failure model was also developed by taking into account the uncertainties of some factors that affect the assembly failure. With this model, the probability of failure as a function of fire exposure time can be generated. The model performance was verified by comparing with the fire test measurements, which demonstrated good agreements. Comparable results are also predicted regarding the fall-off behaviour of the fire-exposed gypsum board as well as the charring behaviour. In addition, an example calculation was made using the probabilistic barrier failure model. Finally, a fire risk analysis case study was conducted on a six-storey apartment building with the purpose of showing the effect of wall barriers on fire risk. Results indicated that CUrisk can evaluate the impact of fire barriers on the fire risk with the new Barrie Failure submodel.